Advancing the Technology of Monolithic CMOS detectors for their use as X-ray Imaging Spectrometers

Completed Technology Project (2017 - 2018)

Project Introduction

The Smithsonian Astrophysical Observatory (SAO) proposes a two year program to further advance the scientific capabilities of monolithic CMOS detectors for use as x-ray imaging spectrometers. This proposal will build upon the progress achieved with funding from a previous APRA proposal that ended in 2013. As part of that previous proposal, x-ray optimized, highly versatile, monolithic CMOS imaging detectors and technology were developed and tested. The performance and capabilities of these devices were then demonstrated, with an emphasis on the performance advantages these devices have over CCDs and other technologies. The developed SAO/SRI-Sarnoff CMOS devices incorporate: Low noise, high sensitivity ("gain") pixels; Highly parallel on-chip signal chains; Standard and very high resistivity (30,000Ohm-cm) Si; Back-Side thinning and passivation. SAO demonstrated the performance benefits of each of these features in these devices. This new proposal high-lights the performance of this previous generation of devices, and segues into new technology and capability. The high sensitivity (~135uV/e) 6 Transistor (6T) Pinned Photo Diode (PPD) pixels provided a large charge to voltage conversion gain to the detect and resolve even small numbers of photo electrons produced by x-rays. The on-chip, parallel signal chain processed an entire row of pixels in the same time that a CCD requires to processes a single pixel. The resulting high speed operation (~1000 times faster than CCD) provide temporal resolution while mitigating dark current and allowed room temperature operation. The high resistivity Si provided full (over) depletion for thicker devices which increased QE for higher energy x-rays. In this proposal, SAO will investigate existing NMOS and existing PMOS devices as x-ray imaging spectrometers. Conventional CMOS imagers are NMOS. NMOS devices collect and measure photo-electrons. In contrast, PMOS devices collect and measure photo-holes. PMOS devices have various attributes that would make them superior for use in X-ray astronomy. In particular, PMOS has: "no" photo-charge recombination; "no" Random Telegraph Signal noise (RTS); and lower read noise. The existing SRI/Sarnoff PMOS devices are small and have been developed for non-intensified night vision applications, however, no x-ray evaluation of a monolithic PMOS device has ever been made. In addition to these PMOS devices, SAO will also evaluate existing NMOS scale-able format devices that can be fabricated in any rectangular size/shape using stitch-able reticles. These "Mk by Nk" devices would be ideal for large X-ray focal planes or long grating readouts. The Sarnoff/SRI Mk by Nk format devices have been designed, with foresight, so that they can be fabricated in either PMOS or NMOS by changing a single fabrication reticle and by changing the type of Si substrate. If X-ray performance results are expected, this proposal will lead the way to future fabrication of Mk by Nk PMOS devices that would be ideal for X-ray astronomy missions such as "X-ray Surveyor". SAO will also investigate the interaction of directly deposited Optical Blocking Filters (OBFs) on various back side passivated devices , and their resultant effects on very "soft" x-ray response. The latest CMOS processes and very fast on-chip, and off-chip digital readout

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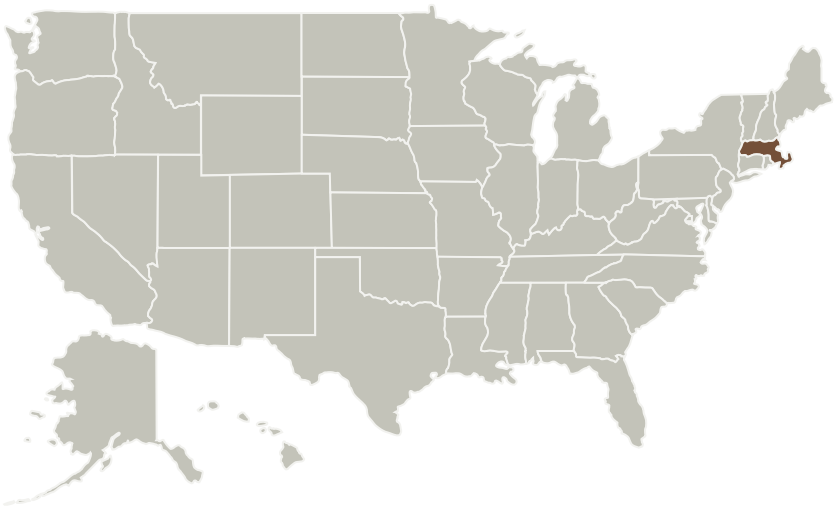
signal chains and camera systems will be demonstrated.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Smithsonian Institution	Lead Organization	Industry	Washington, District of Columbia

Primary U.S. Work Locations
Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Smithsonian Institution

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Almus Kenter

Co-Investigators:

Christine Mcneil
Ralph Kraft
Thomas M Gauron

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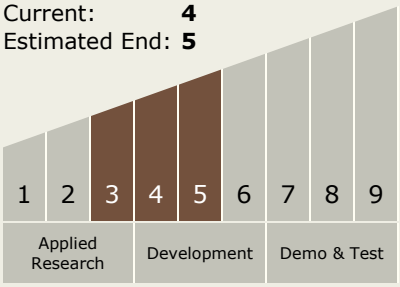
Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System